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HOST-SELECTION IN *PIMPLA EXAMINATOR* F. (HYMENOPTERA)

By Dorothy J. Jackson, F.R.E.S.

With Plate 1.

Pimpla examinator is a well-known parasite of a great variety of Lepidopterous pupae. I have bred this species during several seasons from pupae of *Abraxas grossulariata* L., collected near St. Andrews; usually as a primary parasite, but occasionally as a secondary parasite, the host in this case being *Stenichneumon lineator* F. (*trilineatus* Gmel). I am much indebted to Mr. J. F. Perkins for identifying the species for me and for examining the various females used in the host-selection experiments.

The imagines emerged in July and the early part of August and were ready to oviposit in the autumn, at a time when only small caterpillars of the original host were available, the pupal stage of *A. grossulariata* in Scotland occurring only in the summer. Various Lepidopterous pupae were therefore offered to the females as alternate hosts. Several of the females were isolated and kept under separate observation and some curious facts were observed regarding the reactions of the different females to the same species of host. Little information is available on host-selection in an Ichneumonid recorded from such a wide range of hosts; one does not know whether one individual will oviposit in any of the known hosts accessible, or whether there may be strains within the species addicted to certain hosts. The following observations, though incomplete, bear upon this question, and by recording them it is hoped that a problem deserving of attention may be brought to the notice of others who are engaged in rearing Hymenopterous parasites.

Literature.

P. examinator is widely distributed in the British Isles and in western Europe. It occurs also in Russia, Transcaucasia and western Siberia. In addition to Lepidopterous hosts, it has been recorded from the larvae of the weevil, *Anthonomus pomorum* L., but Meyer (1925) states that this record requires verification. A list of Lepidopterous hosts has been compiled from the records given by Morley (1908), Silvestri (1912), Fahringer (1922), Voukassovitch (1924), Meyer (1925), Faure (1926), Thorpe (1930) and from many references in the 1913–1936 *Review of Applied Entomology*, (A) **1** to **23**. In addition, a few records, marked in the following list with an asterisk, have been given me by Mr. Perkins from labels on specimens of *P. examinator* in the collection at the British Museum (Natural History) at South Kensington. I am much indebted to Dr. K. G. Blair and to Mr. R. Washbourn for the help they have given with the nomenclature of the species listed. Dr. Blair has provided me with the host record of *Sarrothripus reveyana* Scop. The nomenclature adopted is so far as possible that of Meyrick's *Revised Handbook of British Lepidoptera* (1928), and is therefore in some cases not in accord with modern usage. When the names used in the original records differ from these, they have been added in brackets.

List of Recorded Hosts.

PIERIDAE: *Aporia crataegi* L.; *Pieris brassicae* L.; *P. rapae* L. NYMPHALIDAE: *Vanessa polychloros* L.; *V. urticae* L. LYCAENIDAE: *Thecla* *w-album* Knoch.* AEGERIIDAE (SESIIDAE): *Aegeria* (*Synanthedon, Sesia, Trochilium*) *scoliaeformis* Bkh. SARROTHRIPINAE: *Sarrothripus reveyana* Scop. ARCTIIDAE: *Oeonistis* (*Lithosia*) *quadra* L.; *Phragmatobia* (*Arctia*) *cervina* Fallou; *P.* (*Bombyx*) *fuliginosa* L. LYMANTRIIDAE: *Lymantria* (*Bombyx*) *monacha* L.; *Orygyia antiqua** L.; *Euproctis* (*Bombyx*) *phaeorrhoea* Don. (*chrysorrhoea* L.). LASIOCAMPIDAE: *Clisiocampa* (*Malacosoma*) *neustria* L.; *Lasiocampa trifolii* Esper. NOTODONTIDAE: *Cerura* (*Dicranura, Harpygia*) *vinula* L. THAUMATOPOEIDAE: *Thaumatopoea* (*Bombyx*) *processionea* L. THYATIRIDAE: *Palimpsestis* (*Cymatophora*) *octogesima* Hübn. (*ocularis* Guen.). NOCTUIDAE: *Panolis flammea* Schiff. (*griseovariegata* Goetze); *Cucullia artemisiae* Hufn. (*argentea* Hufn.); *Graphiphora* (*Noctua*) *plecta* L.; *Plusia gamma* L. GEOMETRIDAE: *Abraxas grossulariata* L.; *Ennomos quercinaria* Hfn. PYRALIDAE: *Loxostege sticticalis* L. PHYCITIDAE: *Ephestia kühniella* Zell.; *Nephopteryx genistella* Dup.; *N.* (*Metriostola*) *vacciniella* Zell. TORTRICIDAE: *Cacoecia* (*Tortrix*) *piceana* L.; *Tortrix viridana* L.; *Laspeyresia* (*Cydia, Carpocapsa*) *pomonella* L.; *L.* (*Grapholitha*) *molesta* Busck.; *Enarmonia* (*Epinotia, Steganoptycha*) *diniana* Guen.; *Sparganothis* (*Oenophthira*) *pilleriana* Schiff.; *Polychrosis botrana* Schiff.; *Clysia ambiguella* Hübn.; *Exapate congelatella* Cl.; *Evetria* (*Tortrix, Rhyacionia*) *buoliana* Schiff. PSYCHIDAE: *Fumea casta* Pall. (*nitidella* Hb.); *Sterrhopteryx* (*Psyche*) *hirsutella* Hübn. (*cavella* Ochs); *Psyche graminella* Schiff.; *P. viciella* Schiff.; var. *stettinensis* Hering; *Pachythelia* (*Acanthopsyche*) *opacella* Herr.-Schäff.; *P. unicolor* Hufn. HYPONOMEUTIDAE: *Hyponomeuta* (*Yponomeuta*) *evonymella* L.; *H. malinella* Zell.; *H. padella* L.; *H. cognatella* Hübn. OECOPHORIDAE: *Depressaria heracliana* De Geer.*; *Carcina* (*Tortrix*) *quercana* F. GRACILARIIDAE: *Ornix torquillella* Zell.

P. examinator is essentially a pupal parasite, but Fahringer refers to it as parasitising the caterpillars of certain species, and Voukassovitch records *P. examinator* from the larvae of *Hyponomeuta* sp. From the insects so reared he obtained parasitism of the pupae of *Oenophthira pilleriana* Schiff. (a natural host), but he did not succeed in obtaining parasitism of the caterpillars of *O. pilleriana*, only the eggs deposited in the pupae producing imagines.

Contributions to the life-history of *P. examinator* have been made by Meyer and Voukassovitch, while Thorpe deals principally with the characters of the last-instar larva. Voukassovitch, who describes oviposition in this insect, noted that the females tried to oviposit on bare chrysalids removed from their cocoons, and he found that empty cocoons were examined as attentively by the females as those containing chrysalids and were pierced in all directions with the ovipositor. Meyer observed that the females had difficulty in gaining a foothold on slippery pupae and he enveloped the pupae with dust, when oviposition was easily accomplished. Shevirev (1913) stated that he obtained oviposition by *P. examinator* on pupae kept in artificial cocoons of muslin or linen.

LIFE-HISTORY.

P. examinator is an internal parasite. The egg is deposited within the body of the host, and, when laid in early autumn, hatches in about 56 to 72 hours, at room temperature. The larva becomes full grown in about 3 weeks. It then usually fills the host completely, having consumed practically all the host tissue. When feeding is finished it lines the greater part of the pupal shell with a network of golden fawn silk strands and if a hole be made in the cuticle of the host at this time it is closed by the larva with silk. Voukassovitch notes that when *P. examinator* is a parasite of caterpillars, the larva, when full grown, abandons the host and makes a dark chestnut coloured cocoon beside its remains.

The imago emerges from the pupa by cutting away fragments from its anterior end so as to form an irregular hole. It is of interest to note that practically all the specimens bred from *A. grossulariata* collected in the neighbourhood of St. Andrews from 1933 to 1936 were female. In all 38 imagines were reared of which only one was a male. In consequence of this the breeding experiments were commenced with unmated females, and the males reared from these in the late autumn and spring attempted frequently to mate with the old females, but not always successfully, for females, engaged in oviposition, avoid males, though newly emerged females are readily mated. From mated females both sexes were reared.

The females, emerging in July and early August, were usually ready to oviposit in September and October. A female dissected on emergence was found to have the ovaries quite immature. The females mostly survived the winter, both in the laboratory and in the insectary out of doors, some living until the following July and ovipositing in the pupae of *A. grossulariata*, then available. From eggs laid in September (in pupae kept indoors) a partial emergence of males resulted at the end of October and beginning of November. From the remainder of the autumn-laid eggs, full-grown larvae were obtained before the winter. They hibernated in the shell-like remains of the host-pupae. Pupation takes place in spring, and, from material kept out of doors, males were reared in April. In a warm room imagines may be reared in winter. It is doubtful if any males survive the winter as imagines under natural conditions; Seyrig (1924) found females only, hibernating under bark. In very cold weather in winter, the females, when kept out of doors, were found lying torpid on the floor of the case with wings flat against the body and legs drawn in. They revived and became active in mild weather and were seen ovipositing out of doors in February. They continue oviposition until a few days before their death, and from one female, mated in April, a female was reared in July. Females, reared in May 1937, from a mated female, bred in July 1936, were ovipositing in early June, 17 to 25 days after emergence, in pupae of *A. grossulariata*. Their mother was also laying in this host at the same time. It is thus clear that *P. examinator* can produce two generations in the year and the females which succeed in living for a year will augment the number of those ovipositing in June and July. There is little doubt that under natural conditions an alternate host will be required in the autumn.

Oviposition and Development.

The females in captivity have a habit of exploring every part of the cage or receptacle in which they are placed, and any fresh object inserted in it is subjected to the closest scrutiny. Thus a piece of paper, or muslin, a bunch of leaves or any other thin-layered object, is examined attentively by the females with their probing antennae. If a cocoon is introduced it is very quickly found, although the female only seems to perceive it when almost touching it. If the pupa or cocoon was of a type attractive to the female, oviposition was speedily accomplished. The female climbs upon the pupa or upon the cocoon, and, having selected her stance, she proceeds to bore a hole. With a naked pupa, such as *P. rapae*, she assumes the position shown in fig. 1, the ovipositor in this case does not require to be thrust far in. Fig. 2 shows the position adopted at the commencement of oviposition in a small pupa in a leaf cocoon, fig. 3

the position when the ovipositor has been thrust into the pupa. In piercing a large cocoon, in which the pupa is further out of her reach, the abdomen is held in a more vertical position as in fig. 4. The ovipositor may even be thrust in so far that the small cerci at the apex of the abdomen touch the cocoon.

The sheath-like valves, which entirely enclose the ovipositor when at rest, play an important part in oviposition. They are closely applied to the tip of the ovipositor as though guiding it while the site for the puncture is selected, then as the ovipositor (consisting of stylet-sheath and two barbed stylets) penetrates the cuticle, the valves are slipped upwards (figs. 3 and 4), one on each side of the ovipositor. During oviposition the ovipositor is held motionless for some seconds, but a slight patting motion of the valves may take place; then the valves are again lowered to the puncture-hole and the ovipositor is withdrawn, with a slow and characteristic flourish, to its rest position. The female immediately walks away. With thin-cuticled pupae the whole process occupies about 20 to 30 seconds, but with pupae with harder cuticle the boring takes much longer, and a female remained for two hours drilling a hole in a pupa of *Selenia bilunaria* in a leaf cocoon.

The females frequently puncture pupae for feeding purposes only and in this case their method of attack is quite different. Once the ovipositor is thrust through the cuticle a rocking movement of the body takes place and the ovipositor is moved about violently from side to side and backwards and forwards enlarging the hole, the valves are not carefully applied to the ovipositor as in egg-laying but stick out behind the insect. When the female is satisfied with the hole made, she stoops to drink from it, often with the ovipositor still in the hole. If sufficient fluid is not available she will chew at the cuticle with her mandibles, enlarging the hole. While the size of an oviposition puncture is only from 0·23 to 0·3 mm., a feeding hole is much larger, reaching to 0·8 or even 1·4 mm. The female swells most noticeably during feeding, so that the pale pleural membranes become widely extended. When completely gorged the female is forced to desist through being unable to bend. Newly formed pupae in which the cuticle is still soft are of great attraction to the females for feeding, being easily pierced and full of fluid. The females are able to feed on pupae in cocoons by boring a hole through the cocoon into the pupa at a point where the cocoon lies close to the pupa. The fluid which wells up at the puncture is then accessible. The females in captivity frequently pierce pupae in cocoons or beneath muslin in the deliberate fashion characteristic of egg-laying and yet no egg is laid. One may find pupae pierced with many small holes, but sometimes not containing a single egg. This same curious habit has been observed with the females of *Stenichneumon lineator*, which never feed at puncture holes. It would seem that, in captivity, puncturing pupae sometimes becomes a habitual action, unrelated to whether an egg is ready to be laid or not. Pupae which have become riddled with holes usually die, together with any *Pimpla* eggs or larvae they may contain, but from one *P. rapae* pupa that had received 28 punctures a small male pupa was reared. A similar mortality attends the pupae used for feeding, though sometimes, if an egg has been deposited before or after feeding, a parasite may be reared. The most satisfactory way of breeding this ichneumon is to offer pupae, one at a time, to a female, removing each after a short interval. By this means superparasitism is reduced, and also host mortality. As many as 21 eggs have been laid by one female during a 15-hour day.

At a certain interval after an egg has been deposited, the abdomen of the pupa ceases to move in response to external stimuli. With *P. rapae* this happens usually 20 to 24 hours after oviposition, but in rare cases the pupae may remain active for 50 or 60 hours. With pupae in which 3 or more eggs had been laid, movement ceased in from 6 to 12 hours. There can be no doubt that a paralysis occurs similar to that recorded for so many other parasitic and predatory Hymenoptera (Hollande, 1920; Hase, 1924). The actual mechanical puncturing of a pupa does not cause paralysis, as pupae of *P. rapae* that have been punctured only for feeding, remain capable of movement till moribund. There can be little doubt that at the moment an egg is laid some poison is introduced into the host which affects the nervous system, and that, when several eggs are laid in one host, more of the poison is injected. The paralysis cannot be caused through any action of the newly hatched larva, because motion ceases before the larva hatches. Pupae of a suitable host which have received an egg remain in perfect condition until their contents are consumed by the larva. They are undoubtedly alive until the feeding of the larva kills them. As growth is rapid in the later larval stages, the tissues are usually consumed quickly and the larva assumes the pupal state within a " cleaned out " host. In some cases, however, when the host is large, as with *P. brassicae*, the tissues decompose before the larva has completed its development. The host then appears more or less greasy and discoloured, its contents are putrid, and a dead or dying *Pimpla* larva is present in the abdomen. In such decayed pupae a saprophytic fungus often becomes established later, making the recognition of the presence of a dead larva extremely difficult. This fungus has been identified by Mr. T. Petch as *Aspergillus glaucus* (Linn.) Link, which he told me occurs on decaying organic matter of all kinds. A heavy mortality occurred when *P. brassicae* was parasitised by unmated females (the progeny of which are males) only a few of the larvae attaining to a healthy maturity. With a mated female the mortality was lessened and each larva which survived completely filled its host, having consumed all the tissues. From these larvae large females were successfully reared. The same mated female readily attacked pupae of *Ephestia kühniella*, as many as 8 eggs being found in one of these small pupae. Many of these pupae died, and in some a small dead larva was found within the emptied host. Of those that attained the imaginal state in this host 18 were males and 8 females. It seems highly probable that one is concerned here with a differential mortality between the sexes, the male larvae more often dying in large hosts through being unable to consume the tissues before decomposition sets in, and the female larvae sometimes dying in small hosts from insufficiency of food. In medium-sized pupae, such as those of *Pieris rapae*, either sex can develop successfully, though even in this host, for some unknown reason, a good many larvae died in the last instar.

The rearing of a high percentage of females from large hosts and of males from small hosts has been recorded in various ICHNEUMONIDAE and the matter has been discussed by Shevirev (1913), Seyrig (1935) and Holdaway and Smith (1932).

With *P. examinator* a remarkable range of size has been observed in the offspring of a single mated female. Thus a female, bred from *Abraxas grossulariata*, measured 10·7 mm. in length; her largest daughter, bred from *P. brassicae*, measured 14 mm., and her smallest son, from *E. kühniella*, was only 5·6 mm. and a daughter from the same host measured 7·1 mm. Despite the disparity in size, a copulation was observed between a female of 14 mm. and her brother of 8 mm., immediately they were placed together. The males bred throughout these investigations varied in size from 5·6 mm. to 11·5 mm. When such variations of size are possible in the progeny of one female, it is not surprising that species of such different sizes should figure in the list of hosts. Similar results have been obtained by Faure (1926) with *Pimpla instigator*, the insects bred on different hosts varying from 8 to 16 mm.

THE BREEDING EXPERIMENTS.

The rearing of *P. examinator* was begun merely for study of the life-history and without any idea of testing the individual preferences of different females for the same host. It was in fact assumed that a host acceptable to one female would be equally attractive to the others. About a dozen females were kept under observation in the laboratory, each in a separate tumbler covered with muslin. Raisins and diluted honey were supplied to them, and water was provided in a bottle with a cotton wool " wick "; or else water was squirted frequently into the tumbler and a piece of filter paper was put in the foot of the tumbler to collect excess moisture. The experiments were mostly carried out in the autumn and winter of 1933–34, with observations on additional females at the same season during two of the following years, each female being kept under observation for several weeks.

Pupae of *P. rapae* were first offered as hosts and certain females accepted these pupae readily, but other females would not oviposit in them. It was thought at first that such females were sexually immature but it was noticed that they were constantly piercing filter paper, or cotton wool, or muslin, with their ovipositors, and once, when a pupa was offered spun up on a piece of muslin and partly surrounded by it, the ovipositor of the female, thrust into the muslin, reached the pupa and oviposition resulted. In another case a pupa which had slipped under the filter paper was found to have a *Pimpla* egg, dried up, lying on the surface of its body (a most unusual occurrence) and the pupa was not parasitised. It had evidently been lying just out of reach of the female when she thrust the ovipositor through the filter paper. The pupae lying uncovered were ignored by those females. I therefore tried enveloping a Pierid pupa in a muslin bag and then offered it to one of the females. The female was greatly interested and effected oviposition promptly through the meshes of the muslin (fig. 4). The females that had neglected naked pupae laid readily through such artificial cocoons. Later it was found sufficient merely to lay the pupae on the top of the muslin covering the mouth of the tumbler in which the female was confined, holding them in place with another muslin cover. The female, walking on the under surface of the muslin, would poke her antennae through the muslin feeling the pupa and then the ovipositor would be thrust through into the pupa. Successful parasitism of numerous pupae was obtained in this way. It was clear that what was required to stimulate the oviposition instinct of certain females was some sort of cocoon; therefore pupae of various moths in cocoons were offered to the females. Most of the material was obtained from Mr. L. W. Newman, but I am indebted to Mr. W. R. Brough Hynd and to Mr. C. V. B. Herford for supplying additional species. As the females were fairly prolific the difficulty was to keep them supplied with a sufficiency of hosts and a good deal of superparasitism occurred. It was therefore all the more remarkable that some ovipositing females should entirely ignore the naked pupae offered, though such pupae were often left with them for several days.

Results.

Particulars were kept of every pupa offered to each female throughout the weeks during which the observations were made, and the subsequent parasitism or non-parasitism of the pupa noted. Owing to the number of pupae handled it was impossible to dissect them all to ascertain if an egg had been laid, but in most pupae punctures could be detected readily, and the immobility of a pupa soon after being punctured was a sure indication that an egg had been laid. If the pupa was not dissected at an early stage it was kept until the parasite emerged, and even when host and parasite died, as happened often, the presence of a well-grown larva could often be established by dissection long afterwards.

The results of the observations on the different females showed that some would lay readily in either naked or cocoon pupae, one or two occasionally attacked a naked pupa, sometimes only for feeding, and then ignored them for long intervals, and others would not oviposit at any time in a naked pupa.

One female laid with the utmost readiness and regularity in naked pupae of *brassicae* and *rapae.* I had merely to drop the pupa, unattached, into her tumbler and she mounted it and laid. During a month this female punctured 82 pupae of *rapae* and *brassicae,* and from these 117 parasites in different stages were obtained, and doubtless many more eggs were laid, as only a few of the hosts were dissected soon after parasitism when the degree of superparasitism could be ascertained readily.

Another female, placed in a glass in which *rapae* pupae were spun up, utterly ignored them, but punctured 104 pupae of *rapae, napi* and *brassicae* placed on the outside of the muslin, and laid many eggs in them. The pupae on the inside of the glass, which she must have crawled over many times a day throughout many weeks, remained unscathed, but when some of these were removed and placed on the surface of the muslin she laid in them readily. She also attempted to lay in a *rapae* pupa which I had pushed into a fibre cocoon formed by a Geometrid larva.

Another female refused naked pupae after being supplied with pupae in cocoons; another, having parasitised cocoon pupae freely, only began to lay in naked pupae when one slipped out of a cocoon which she was examining.

Another female, which during the autumn of 1936 had punctured numerous pupae of *Selenia bilunaria* in leaf cocoons in a case out of doors, was brought under observation in January. She then oviposited readily in naked pupae of *rapae, brassicae* and *P. aegeria,* accepting at the same time various pupae in cocoons, or in muslin; going freely from a cocoon pupa to a naked pupa and vice versa (figs. 1 to 4 are of this female). The only pupae ignored by her at this time were the butterfly-like pupae of the Geometrid, *Leucophthalmia annulata,* which were attached to a leaf and largely exposed to view. Latterly, however, the habits of this female changed and she took no interest in the naked pupae of *napi* and *brassicae* offered to her. During the interval she had been supplied with new hosts in cocoons, *Calocalpe certata, Meliphora grisella* and *Ephestia kühniella,* species which she attacked eagerly, actually laying 5 eggs in one of the small wax-moth pupae. During this time, for 10 days, a *brassicae* pupa had been exposed to her, but was ignored. However, within 3 minutes of my covering this pupa with muslin she oviposited in it, and she also laid in pupae of *napi* when muslin was laid over them. It would seem as though her instinct for oviposition in naked pupae had been blotted out by the attraction of the cocoon species recently offered.

Females kept out of doors throughout the winter in a large case with *Selenia* pupae, eagerly parasitised pupae of their own host species, *A. grossulariata,* the following summer. They also oviposited in the full-grown larvae which were spinning their cocoons, but such parasitised larvae died. The young caterpillars of *A. grossulariata* were ignored by the females. Full-grown

Pierid caterpillars were of some interest to certain females, but I did not obtain any evidence of the successful parasitism of caterpillars.

Apart from the curious dependence of certain females on having a cocoon to oviposit in, other individual preferences were not observed, but these may well occur under natural conditions with a wider choice of hosts. All types of cocoons were attacked without the slightest hesitation, but usually the cocoons of large species were less attractive. Thus a moss-covered cocoon of *E. versicolor* which was offered to one female aroused only slight interest in her, and though she pierced the cocoon occasionally with her ovipositor, the cuticle of the pupa was evidently too hard for her and she soon desisted from her efforts. Another female, however, made repeated attempts to oviposit in *Cerura vinula*. She succeeded in piercing the hard bark-like cocoon but she failed to puncture the pupa. The females discover a cocoon of any sort with amazing promptitude. Merely walking on a surface which is hollow arouses their interest. The antennae are bent down to feel the surface, and, if the insect is still curious, the ovipositor is inserted. Any swelling is carefully examined, and the convex surface of the folds on corrugated paper arrested the attention of one female and she thrust her ovipositor deeply into it. A piece of branch containing several cocoons of *H. abruptaria* was placed with this female. These cocoons were made of fragments of bark so exactly resembling in colour and texture the actual bark that I could only discover which was a cocoon by prodding it. The female had never seen such a cocoon before, but, the moment she crawled upon the stick, she detected them and oviposited immediately and successfully. Empty cocoons were examined by the females and the ovipositor may be thrust into them, only to be withdrawn quickly. Cocoons containing hatched pupae or dead larvae are also pierced, but no egg is laid. For the emission of the egg (apart from the very rare incident mentioned above) it would seem that a certain tactile sensation (probably of a certain degree of resistance and of moisture) has to be experienced. A female has been seen to puncture a dead pupa of *P. rapae*, but she withdrew her ovipositor instantly; had the chrysalis already contained an ichneumon larva, an egg might have been laid as in *A. grossulariata* parasitised by *Stenichneumon lineator*.

The results obtained with the various pupae offered are shown in the following list. Several species in cocoons were so highly attractive to the females that they were riddled with holes and died, so that no adult parasites were reared from them. This largely explains the number of species listed in the second category, but does not indicate that such species are unsuitable as hosts. Cocoon species were offered in cocoons; sometimes additional specimens were offered naked, but these were only punctured by certain females. Some pupae (marked with an asterisk) being received naked, were put into leaf or fibre cocoons of other species. The butterfly pupae were only punctured, naked, by certain females.

List of Species offered as Hosts.

The figures after the specific name record the results obtained, and apply as follows :—

1. Species from which full-grown, healthy larvae, pupae or adults have been reared.
2. Species punctured by females but from which no adult parasites have yet been reared.
3. Species which females tried to puncture, but unsuccessfully.

4. Species ignored. Exposed to one or more females for several days or longer. The cocoon of *S. pavonia* was examined by one female but no attempt at oviposition was witnessed.

Pieridae : *Pieris brassicae* L. 1.; *P. rapae* L. 1.; *P. napi* L. 1. Satyridae : *Pararge aegeria* L. 1. Arctiidae : *Diacrisia* (*Spilosoma*) *lubricipeda* L. 3.; *D. menthastri* Esper. 3.; *Tyria* (*Hipocrita*) *jacobaeae* L.* 3. Saturniidae : *Saturnia pavonia* L. 4. Endromididae : *Endromis versicolora* L. 3. Drepanidae : *Falcaria* (*Drepana*) *lacertinaria* L. 3.; *F. falcataria* L. 2. Notodontidae : *Cerura vinula* L. 3.; *Odontosia* (*Lophopteryx*) *camelina* L. 3.; *Drymonia* (*Notodonta*) *trepida* Esp. 4.; *Pygaera pigra* Hufn. (*reclusa* F.) 2. Noctuidae : *Euclidia glyphica* L. 3. Geometridae : *Leucophthalmia annulata* Schulze (*omicronaria* Hübn.) 4.; *Selenia bilunaria* Esper 1.; *S. tetralunaria* Hufn. (*illustraria* Hübn.) 2.; *Cephis advenaria* Hübn.* 2.; *Synopsia* (*Hemerophila*) *abruptaria* Thnbg. 1.; *Pseudopanthera* (*Lozogramma*) *petraria* Hübn. 1.; *Deilinia* (*Cabera*) *pusaria* L. 1.; *D. exanthemata* Scop.* 2.; *Plemyria* (*Eulype*) *hastata* L.* 2.; *Calocalpe certata* Hb. 1. Phycitidae : *Ephestia kühniella* Zell. 1. Galleriidae : *Meliphora* (*Achroia*) 3; *grisella* F. 2.

Discussion of Results.

In considering the facts brought forward it must be remembered that all the experiments have been carried out on insects closely confined and with a limited choice of host. When, under such conditions, a strong tendency is shown to avoid certain hosts, it is hardly to be doubted that in a state of nature these aversions will operate more strongly, as the female will be free to wander off in search of a more attractive host. A practical point of great importance bearing on any host-selection work is to know how long a mature female can hold back her eggs if no host to her liking is available. One female of *P. examinator*, emerged like the others in July, was placed for the first time with pupae (naked pupae of *P. rapae*) on 15th September. She took no interest in them and she was dissected on 30th September, when it was found that several of her ovarian tubules contained mature eggs which had regressed. These eggs had become shrunken and hollow, the contents turning brown. Healthy eggs were also present in some of the tubules. This female must have become sexually mature earlier than the others, at a time when she had not access to pupae. Further investigations on this matter are required, but it is probable that eggs can be retained indefinitely without injury to the female. If laying is resumed, the regressed eggs, in which the chorion has been fully formed, will presumably have to be disposed of, and this may well be the explanation of the infertile egg sometimes laid by ichneumons. Flanders (1935) in his study of the Pteromalid, *Peridesmia phytonomi*, found that if environmental conditions prevented oviposition, the ovarian follicles and the eggs apparently disintegrated and were absorbed.

The differences in the reactions of the various females to the same pupae and the variations in the habits of the same female during her lifetime are matters very difficult and perhaps impossible to explain. The factor effecting the decision of the females in many cases is the presence or absence of a cocoon. It is clear that a choice determined on such a basis is purely psychological and is not determined by the suitability or otherwise of a certain host, as a perfectly suitable host may be ignored if not enclosed in some sort of a cocoon. The view of Picard (1921) that oviposition in *Pimpla instigator* is a simple reflex stimulated by an olfactory sensation, cannot apply in this case; the matter is much more complicated and dependent on the mental bias inherent in the female at the time the pupa is presented to her. It may be suggested that fear of injury prohibits a female from attacking an exposed pupa, but in nature exposed pupae are firmly attached to some support, and the movement of the abdominal segments of the pupa could do little to injure the female which usually takes her stance on or near the thoracic region. Moreover, certain females in captivity readily attacked even large pupae, such as *brassicae*, when loose and rolling about, despite the danger of being hurt, and such females would continue their assault on naked pupae even though crippled with an injured leg. Faure (1926), who has studied the oviposition of *Pimpla instigator*, shows that this species is a polyphagous parasite attacking various pupae in cocoons, but having a preference for Lepidoptera with naked chrysalids, such as those of the genera *Pieris*, *Aporia* and *Papilio*. *P. examinator* might be summarised as a polyphagous parasite sometimes attacking naked pupae, but having a preference for pupae in cocoons.

Little is known of the factors determining the choice of host in an ichneumon. Some authors consider that ovipositing adults show a preference for hosts of the same species as that in which they have themselves developed. Salt (1931), however, has observed that females of *Hemiteles hemipterus* F., bred from larvae of *Cephus pygmaeus*, refused to oviposit in larvae of their own host species though readily attacking the larvae of certain other species presented to them, and he considers that this indicates the definite selection of an alternate host by ovipositing females. The females of *Pimpla examinator* show, on the contrary, a very strong attraction to their own host pupae when these become available. It seems possible that with this polyphagous species there may be strains imbued with the instinct to oviposit in certain types of hosts, or perhaps even in a certain sequence of hosts. The pupa of *A. grossulariata*, largely exposed to view within its flimsy cocoon, may be considered as intermediate between a naked and a cocoon species. Perhaps in parasitising this host two strains may meet, one addicted only to cocoon pupae and another having a wider range of hosts. Such a hypothesis could only be tested by extensive breeding experiments, and it is clear that one must be cautious in any conclusions regarding a matter as little understood as the instinctive behaviour of insects. Thompson and Parker (1927) have, indeed, expressed the opinion that "the laws underlying host relations are not capable of expression in scientific terms nor discoverable by scientific methods."

SUMMARY.

A list is given of the recorded hosts of *Pimpla examinator* F.

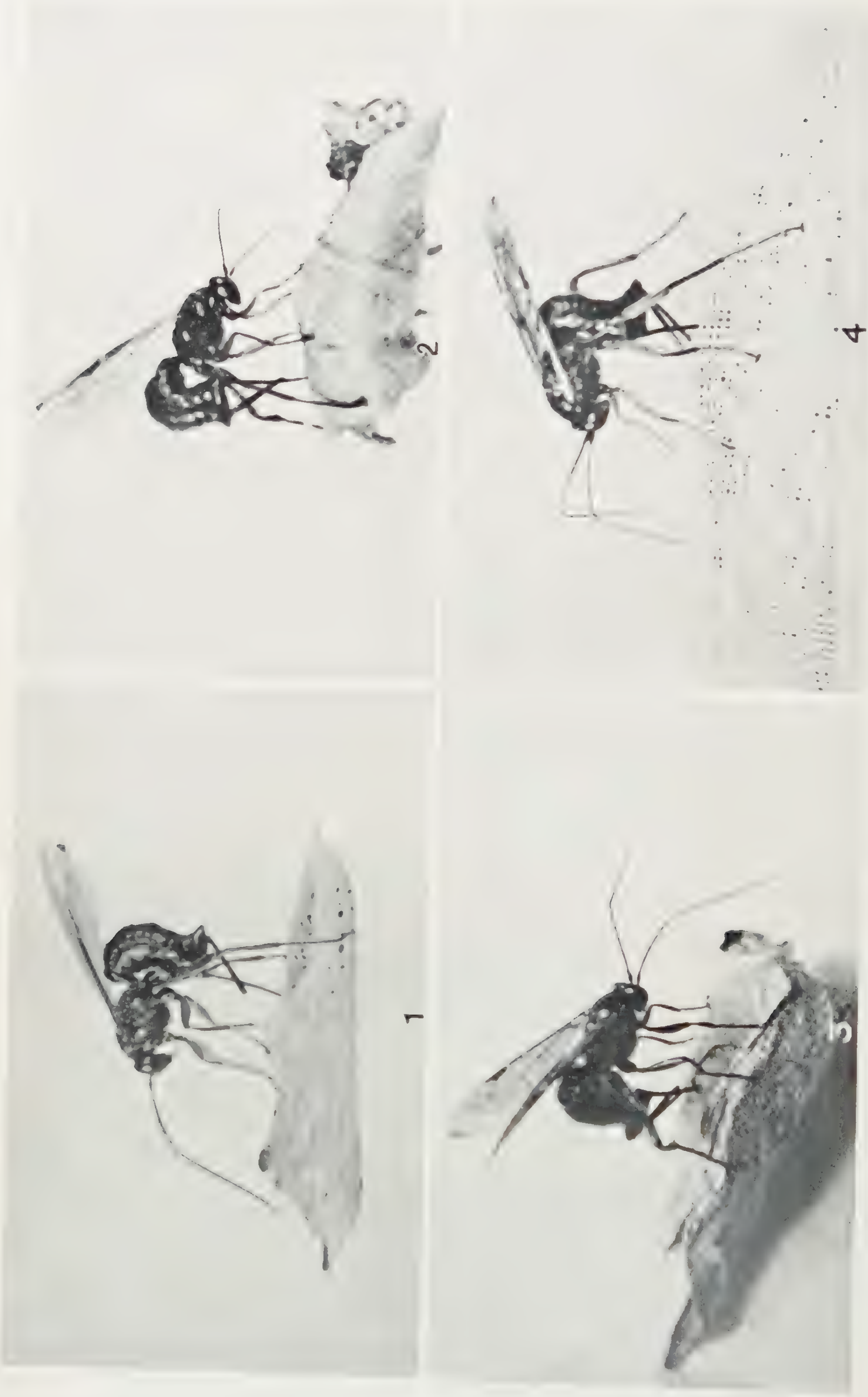
The life history of this species is summarised, and the habits of the female in puncturing pupae for feeding and oviposition are described.

The development of the larva in hosts of different sizes is discussed, and a wide variation in the size of the offspring of a single mated female is recorded.

Females bred from pupae of *Abraxas grossulariata* were offered pupae of various Lepidoptera as alternate hosts.

Differences were observed in the reactions of the different females to pupae of the same species, some individuals readily ovipositing in naked pupae, such as the pupae of *Pieris rapae*, but other females interesting themselves only in pupae within real or artificial cocoons.

A number of species differing widely in size and habit were successfully parasitised.



Host-selection in ***Pimpla examinator*** **F.**

ENGRAVED BY STAR ILLUSTRATION, LONDON.

Plate 1.

Figs 1–4.—*Pimpla examinator* F. 1. Female ovipositing on pupa of *Pieris rapae* L., 2. female puncturing leaf-cocoon of *Falcaria* (*Drepana*) *lacertinaria* L., 3. female ovipositing in leaf-cocoon of *Pygaera pigra* Hufn., 4. female ovipositing on pupa of *Pieris brassicae* L., enveloped in muslin. All magnified about 3½ times.

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THE EFFECT OF DELAYED FERTILISATION ON THE SEX RATIO OF A SPECIES OF INSECT IN WHICH THE FEMALE IS THE HETEROGAMETIC SEX (*EPHESTIA KÜHNIELLA* ZELL. LEPID., PHYCITIDAE)

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In two phyla of vertebrates it has been demonstrated that delay in fertilisation is followed by an increased proportion of males in the resulting progeny. Hertwig (1) and Kuschakewitsch (4) long ago showed that in the frog overmature ova produced a larger proportion of males than ova from females mated at the normal time. Later Mrsic (6) found that the sex ratio of the trout could be altered in a similar way, and there is also some indication in the domesticated mammals that the proportion of males is greater from very mature ova.

Table 1.

A series of 19 family sex ratios of *Ephestia kühniella* Zell. from females fertilised one week after emergence and the resulting progeny reared at a constant temperature of 23° C.

No. of ♀	♂♂	♀♀	Total progeny	Family sex ratios ♂♂ per 100 ♀♀
1	134	150	284	89·33 +
2	108	172	280	62·79 +
3	108	166	274	65·06 +
4	126	146	272	86·30 +
5	103	115	218	89·57 —
6	93	99	192	93·94 —
7	94	91	185	103·30 —
8	83	101	184	82·18 —
9	88	94	182	93·62 —
10	79	98	177	80·61 +
11	88	87	175	101·15 —
12	80	86	166	93·02 +
13	72	94	166	76·60 —
14	89	76	165	117·11 —
15	80	84	164	95·24 +
16	64	94	158	68·08 +
17	74	83	157	89·16 —
18	30	36	66	83·33 +
19	28	24	52	116·67 +
	1621	1896	3517	1687·06

The mean of the family sex ratios of the above series of females $= \frac{1687 \cdot 06}{19} = 88 \cdot 79 \pm$ 3·426 ♂♂ per 100 ♀♀.

Recently I have found that a similar phenomenon may occur in the Insecta. In carrying out experiments designed to discover whether parthenogenesis occurs in the species *Pseudococcus citri* Risso (Hemiptera), it was necessary to maintain a large number of adult virgin females for long periods in isolation

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from males. No parthenogenetic reproduction occurs, but if the over-mature females are fertilised before they begin to exhibit indications of moribundity, sexual reproduction is found still to be possible, but the resulting sex ratios showed an abnormally large proportion of males and the increased proportion of males varied directly with the length of the period of delay before fertilisation (2). Although the examples cited above are by no means sufficient to suggest that it is an invariable rule in the animal kingdom that the postponement of fertilisation is followed by an abnormal production of males, it is nevertheless possibly of some significance that in each case investigated so far the female is the homogametic sex.

The principal theory advanced to account for the higher proportion of males from late fertilised zygotes is that an increased maturity of the ova causes an increased tendency towards primary non-disjunction of the X-chromosomes (only possible, of course, in the ovum when the female is the homogametic sex) and their extrusion into the polar body with the consequent production of males of the XO type.

Although it seems probable that the female of *P. citri* is homogametic (Schrader), it also appears that one sex is represented by a group of five closely associated chromosomes which behave together in certain respects like a heterochromosome, and it is doubtful whether non-disjunction can be accepted as an adequate explanation of the phenomenon in *Pseudococcus*.

Consequently, I decided to test the validity of the non-disjunction theory by investigating the effect of delayed fertilisation on the sex ratio of a species of insect in which the female is the heterogametic sex. *Ephestia kühniella* Zell. was the species selected, because its chromosome constitution is eminently suitable for the purpose and it can be readily reared in the laboratory.

Wagner (9) and Kühn and Henke (3) have shown that the X-chromosome arrangement in *E. kühniella* is XX in the male and XO in the female. The diploid number of chromosomes for the species is 60 in the male and 59 in the female; all the spermatozoa contain 30 chromosomes each including an X-chromosome, but only half the ova contain 30 chromosomes as the remaining half lack the X-chromosome and have only 29 each.

Now, if non-disjunction of the X-chromosomes in the female is the sole cause of the increased proportion of males resulting from over-ripe ova, the sex ratios of *Ephestia* should be unaffected by the delay of fertilisation, since the X-chromosome is unpaired in the female. On the other hand, if the phenomenon is indeed entirely controlled by the elimination of a particular chromosome or chromosomes from the ovum, an increased proportion of females could result from a possible increased tendency in over-ripe ova for the unpaired X-chromosome to be extruded into the polar body at reduction, thus ensuring (in cases where the female is the heterogametic sex) that these eggs will produce females on fertilisation. Hence it was a matter of some interest to submit heterogametic ova to the effect of delayed fertilisation.

Not only was it necessary that the species of insect chosen for the experiment should be genetically suitable, but it was also very desirable that the ovaries should contain a large number of ova ready for fertilisation immediately after emergence, so that any selected experimental period of delay before fertilisation should have a known and comparable significance. Fortunately in this respect also *E. kühniella* fully met the requirement of the experiment, since Norris (7) has shown that the ovaries of this insect contain a large number of mature ova at the time of emergence, and the dissection of a series of females proved completely confirmatory of the fact.

The progeny of each female was reared in a closed petri dish on an ample supply of oatmeal, all of which was taken from the same bulk quantity, and though the food underwent gradual partial desiccation during the course of the experiment so as to cause the humidity of the air enclosed within the petri dishes to fall from between 80 and 90% to between 40 and 50% R.H., the effect was uniformly felt by the progeny in each petri dish. All the females were fertilised by freshly emerged males from the same stock.

Table 2.

A series of 23 family sex ratios of *Ephestia kuhniella* Zell. from females fertilised immediately after emergence and their progeny reared at a constant temperature of 23° C.

No. of ♀	♂♂	♀♀	Total progeny	Family sex ratios ♂♂ per 100 ♀♀
1	120	136	256	88·24 —
2	108	142	250	76·06 —
3	115	103	218	111·65 +
4	80	110	190	72·73 —
5	86	101	187	85·15 —
6	88	96	184	91·67 —
7	98	86	184	113·95 +
8	83	92	175	90·22 —
9	68	90	158	75·56 —
10	75	81	156	92·59 +
11	71	83	154	85·54 +
12	75	76	151	98·68 +
13	70	67	137	104·48 +
14	46	83	129	55·42 +
15	68	60	128	113·33 +
16	58	64	122	90·625
17	70	46	116	152·17 +
18	58	54	112	107·41 —
19	38	66	104	57·58 —
20	46	44	90	104·55 —
21	32	48	80	66·67 —
22	36	36	72	100·00
23	12	16	28	75·00
	1601	1780	3381	2109·27

The mean of the family sex ratios of the above series of females $= \frac{2109\cdot27}{23} = 91\cdot71 \pm 4\cdot454$ ♂♂ per 100 ♀♀.

Two experiments were carried out. In the first, a series of thirty females was fertilised seven days after emergence and the sex ratio of their progeny was compared with that of thirty females of the same stock fertilised immediately after emergence; both the progeny from the delayed matings and those of the controls were reared in incubators at a constant temperature of 23° C. However, eleven of the females whose mating was delayed failed to produce living progeny, whilst seven of the females fertilised at emergence proved to be sterile.

Tables 1 and 2 give the proportion of the sexes in the progeny of the fertile females from the delayed matings and from the fertile control females respectively.

It will be seen that, despite the delay of seven days to which the females in Table 1 were subjected before mating occurred, the mean of their sex ratios when compared with the mean of the sex ratios of the females in the control experiment failed to show a significant difference.

In the second experiment fourteen days were allowed to elapse before mating. The progeny were reared in petri dishes as in the previous experiment, but it was necessary to place them together with the petri dishes containing the progeny of the females of the control experiment in a glasshouse in which the temperature varied from 23·24° C. to 37·73° C., giving a mean temperature for the period of the experiment of 30·85° C.

Table 3.

A series of 21 family sex ratios of *E. kühniella* Zell. from females fertilised 14 days after emergence.

No. of ♀	♂♂	♀♀	Total progeny	Family sex ratios ♂♂ per 100 ♀♀
1	84	69	153	121·74 —
2	51	81	132	62·96 +
3	48	78	126	61·54 —
4	60	64	124	93·75 +
5	48	57	105	84·21 +
6	42	51	93	82·35 +
7	40	51	91	78·43 +
8	42	45	87	93·33 +
9	42	43	85	97·67 +
10	36	48	84	75·00
11	29	36	65	80·55 +
12	30	35	65	85·71 +
13	50	10	60	500
14	15	35	50	42·86 —
15	21	19	40	110·53 —
16	9	30	39	30·00
17	18	18	36	100·00
18	9	21	30	42·86 —
19	15	12	27	125·00
20	9	21	21	75·00
21	6	15	21	40·00
	704	839	1534	2083·49 +

The mean of the family sex ratio $= \frac{2083{\cdot}49}{21} = 99{\cdot}05$ — ♂♂ per 100 ♀♀.

A series of fifty females was utilised together with a corresponding number in the control experiment. Of the females whose fertilisation was delayed, twenty-nine females were sterile or sterility was induced by the conditions of the experiment, whilst twelve females in the control experiment failed to produce offspring.

Tables 3 and 4 give the proportion of the sexes in the progeny of the fertile females.

TABLE 4.

A series of 38 family sex ratios of *E. kühniella* Zell. fertilised immediately after emergence.

No. of ♀	♂♂	♀♀	Total progeny	Family sex ratios ♂♂ per 100 ♀♀
1	120	142	262	84·51 —
2	127	128	255	99·22 —
3	97	147	244	65·99 —
4	105	126	231	83·33 +
5	119	111	230	107·31 —
6	105	124	229	84·17 +
7	93	116	209	80·17 +
8	94	113	207	83·19 —
9	102	105	207	97·14 +
10	93	106	199	87·74 —
11	99	99	198	100·00
12	90	106	196	84·91 —
13	99	96	195	103·125
14	94	90	184	104·44 +
15	86	97	183	88·66 —
16	84	97	181	86·60 —
17	83	91	174	91·21 —
18	80	92	172	86·96 —
19	74	84	158	88·10 —
20	67	89	156	75·28 +
21	88	67	155	131·34 +
22	76	73	149	104·11 —
23	71	70	141	101·43 —
24	72	64	136	112·50
25	71	63	134	112·70 —
26	59	71	130	83·10 —
27	57	60	117	95·00
28	55	61	116	90·16
29	61	51	112	119·61 —
30	57	52	109	109·62 —
31	64	42	106	152·38 +
32	53	51	104	103·92 +
33	50	42	92	119·05 —
34	43	46	89	93·48 —
35	54	31	85	174·19 +
36	35	41	76	85·27 —
37	37	32	69	115·625
38	26	20	46	130·00
	2940	3096	6036	3816·04

The mean of the family sex ratios of the above series of females $= \frac{3816{\cdot}04}{38} = 100{\cdot}42 \pm 3{\cdot}476$ ♂♂ per 100 ♀♀.

A comparison of the fecundity of the females in Table 3 with that of the females in the other three series shows that the long delay before fertilisation at the rather high temperature of the experiment has obviously greatly lowered their fecundity, and a few of the ratios from the less prolific females at the lower end of Table 3 show violent fluctuations which may be regarded as cancelling out.

The principal value of the second experiment lies in the fact that, despite the relatively long delay before fertilisation, there is no indication of the emphatic and unanimous tendency in the family sex ratios towards an increased proportion of one sex such as was observed in the family ratios from very over-mature ova in *Pseudococcus* (2).

I wish to thank Mr. R. P. Bumstead for assistance in the day-to-day work of rearing and sexing the progeny, a task which extended over a period of eight months.

SUMMARY.

(1) Delayed fertilisation of the ova of *Ephestia kühniella* Zell. produces no significant alteration in the sex ratio.

(2) Two experiments were carried out. In the first a delay of seven days was made. Out of thirty females whose fertilisation was thus delayed, nineteen were fertile and produced 3517 individuals, of which 1621 were males and 1896 were females, giving a sex ratio for the series of 88·79 ± 3·426 ♂♂ per 100 ♀♀. Twenty-three females out of the thirty employed in the control experiment which were fertilised immediately after emergence produced 3381 individuals, of which 1601 were males and 1780 were females, giving a sex ratio for the series of 91·71 ± 4·454 ♂♂ per 100 ♀♀. Thus the mean of the family sex ratio of the females whose fertilisation was postponed falls within the limits of the standard error of the mean of the family sex ratios of the females of the control experiment which were fertilised immediately after emergence. The progeny of both series of females were reared at a constant temperature of 23° C.

(3) In the second experiment fourteen days were allowed to elapse before mating, and the twenty-one fertile females out of the fifty so treated produced 1534 individuals, of which 704 were males and 830 were females, giving a sex ratio for the series of 99·05 ♂♂ per 100 ♀♀. Thirty-eight fertile females out of the fifty employed in the control experiment produced 6036 individuals, of which 2940 were males and 3096 were females, giving a sex ratio for the series of 100·42 ± 3·476 ♂♂ per 100 ♀♀. Hence, notwithstanding a period of delay double that in the first experiment, no significant alteration of the sex ratio became evident. The progeny from both series of females were reared at a mean temperature for the period of the experiment of 30·85° C., and the temperature varied from 23·24° C. to 37·73° C.

(4) Since the female of *E. kühniella* is of the XO type and delay in fertilisation is shown to have no significant effect on the sex ratio, the result may be regarded as affording evidence of a negative kind in support of the theory that the increased proportion of males in the progeny from delay matings is due to non-disjunction of the X-chromosomes when the female is the homogametic sex.

(5) The result also shows that the converse phenomenon of an increase in the proportion of females from the over-mature ova of heterogametic females does not occur at any rate in *E. kühniella*.

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Book Notice.

Biological processes in tropical soils, with special reference to Malaysia. By A. Steven Corbet. 8vo. Cambridge, W. Heffer & Sons, Ltd., 1935. Price 7*s.* 6*d.* pp. xiv + 156, 16 pls., 10 figs.

This book is addressed to all concerned with the soil in tropical countries and it is written in non technical language to make it intelligible to the planter and agriculturist.

Its entomological interest is almost restricted to the effect of the actions of termites in the soil. The importance of the insects may be judged from the fact that in an index to animals one sixth of the entries relate to termites. The plant index is considerably longer. An appendix is devoted to standard methods employed for the examination of soils, classification of fungi and bacteria, conversion factors, and a bibliography. At the end of each chapter is given a list of relevant literature.

NOTES ON THE HIBERNATION AND COURTSHIP OF *NYMPHALIS IO* (L.) (LEPIDOPTERA)

By Oswald H. Latter, F.R.E.S.

Hibernation.

In a note communicated to the Society last year (1936, *Proc. R. ent. Soc. Lond.*, **11:** 96), I suggested that intensity of light may perhaps be a factor in determining the onset and the close of hibernation in *Aglais urticae* (L.). Observations that I made on a male *Nymphalis io* during last autumn seem to point to the same conclusion, or at any rate to temperature not being the sole determining cause. On 7 September, 1936, this male *N. io* took up winter quarters in the deep shadow beneath the wash-basin in my lavatory sometime between 1.0 p.m. and 4.20 p.m. (Summer time). The basin is immediately below the window, which is hardly wider than the basin itself; thus at no time can direct light through the window reach the spot selected by the butterfly. The window faces west, and the sun shines on it for an hour or so in the late afternoon, a hill and trees shutting it out soon after 5.0 p.m. The day was dazzlingly bright; there had been some rain during the preceding night, and the wind had veered to W.N.W. producing the " hard " brilliant sky that is so characteristic of the time when a depression-centre has just passed to the eastward of us. The maximum shade temperature for that day as registered by my Kew-certified instrument in the Stevenson screen was 66·0° F., and at 4.20 p.m. when I discovered the insect the temperature was 64·0° in the screen; and I satisfied myself on several occasions that the temperature in the lavatory, taken within six inches of the butterfly, was within less than 1 degree the same as that in the screen.

That high temperature is not the sole factor in rousing an insect from hibernation seems clearly shown by the fact that this *N. io* remained motionless in spite of the shade temperature exceeding 70° F. on five days between September 9 and 23, being as high as 73·0° F. on the 11th; whereas on 5 April, 1937, *N. io* was on the wing in my garden, the day being very sunny but the maximum temperature only 60·1° F.

My specimen remained motionless until 16 October, when for some unknown reason it moved on to a fire-extinguisher that stood under the basin. From 17 October to 26 November it continued restless, walking about on the floor, generally with its wings partly spread out. There was a short spell of mild weather from 16 to 26 October with maxima of 60° F., or slightly above on six days, and none below 52° F. These wanderings took place almost every day to a greater or less extent, except from 23 to 25 November, which were cold and foggy and with maxima below 40° F., whether the sky was bright or cloudy and dull, but were certainly more marked on sunny days. I noticed that when the butterfly came to rest each afternoon it showed a distinct preference for the junction of a dark with a light surface; sometimes it settled down just at the edge of the shadow cast by the basin on to a piece of dark carpet on the floor, and well away from the walls; at other times it rested on the edge of the carpet close to the white skirting; or, if it had left the carpet, on one of the dark slate-coloured tiles abutting on the skirting.

On 22 November, at the suggestion of Sir Edward Poulton, I placed a small palette containing sugar solution close to the insect; and shortly after doing so I found it standing with its head over the palette, and believe that it had sucked up a little, though I did not witness the action. On 26 November the morning was very bright and the insect walked about for some time; but in the afternoon it came to rest on the carpet and against the white skirting, and on the edge of the shadow of the basin, whence it never moved.

On 26 April, 1937, as *N. io* had been on the wing out of doors for more than two weeks, I closely examined my specimen and found it to be dead, although its wings were still close together and upright as in life. I am unable to state when death had occurred. I had hoped to secure a note of the meteorological conditions when hibernation came to an end; the observations made seem, however, worth recording.

COURTSHIP.

It is probable that the epigamic behaviour of *N. io* is identical with that of *A. urticae* described by Poulton (1904, *Proc. ent. Soc. Lond.*, **1904** : xlii; and 1931, **5** : 99, where other references are included), namely that the male taps with his antennae on the hind-wings of the female. On 23 April, 1937, at Sandhurst, Berks, I saw two *N. io*, one clearly in pursuit of the other. Twice they alighted, wings widely outspread, on a sunlit bank, and on each occasion the male was immediately behind the female, his head almost in the space between her hind-wings. The position was such that he could tap her wings with his antennae, but I was not near enough actually to observe this being done.

BOOK NOTICE.

The soul of the white ant. By E. N. MARAIS, translated by W. de Kok. London, Methuen & Co. Price 7*s*. 6*d*. pp. xv + 184, 8 pls., 9 figs.

This work is a translation from the original written in Africaans and published in South Africa, at first as a number of articles in journals and later collected into book form.

The experiments described and the conclusions reached are the result of original investigations made by the author on termites in South Africa.

An unusual comparison of a termitarium with a human body is made. The author suggests that the castes of termites and the numerous individuals represented in a termitarium are to be compared with the various parts of the body, the white and red blood corpuscles representing the soldier and worker castes and so on.

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